

# Adapting Now to a Changing Climate

Wallops Flight Facility and the Eastern Shore



climate risks

# the issue

Climate data collected over the past 60 years in the Wallops Flight Facility Area show a long-term pattern of sea level and temperature rise. Data from Salisbury, Maryland indicate that the average annual temperature has risen approximately 1.2 degrees over the past century. Data from Kiptopeke, Virginia show that sea level has risen about 7 inches during the past sixty years.

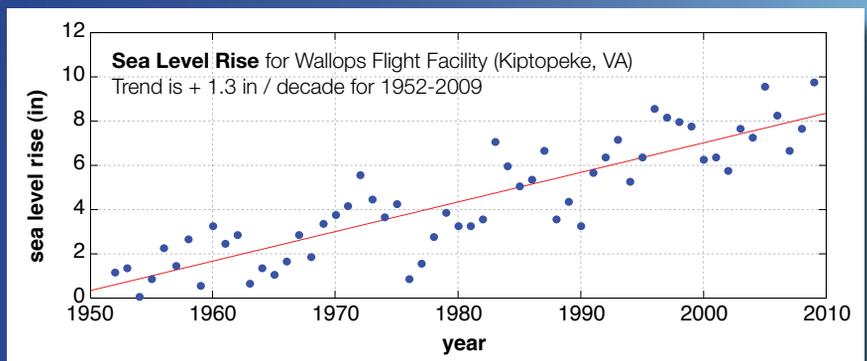
Climate models project continued sea level rise and warmer temperatures in the region. Along with sea level rise, storm surges from hurricanes and nor'easters may increasingly make natural and built systems vulnerable to disruption or damage. Government agencies and other organizations, including utilities, planning commissions, conservation groups, and research institutions are currently assessing the potential of climate hazards to affect the region and their operations.

This handout can help area leaders (NASA together with its tenants, neighbors, and area partners) understand what they may expect in the future, and plan accordingly.

## What's already happened *locally*?

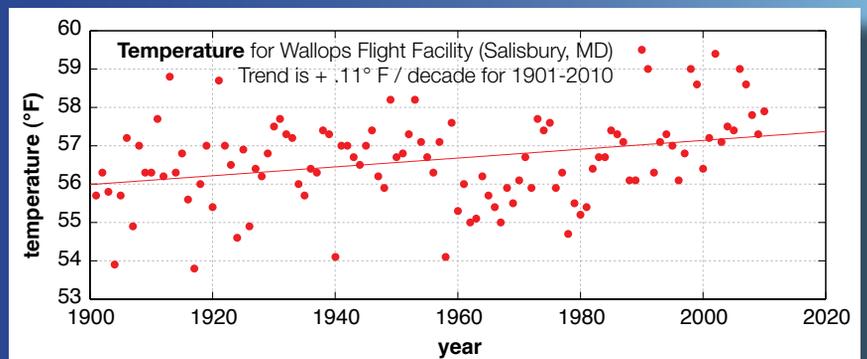
### Sea Level

has risen over decades, though individual years vary somewhat



### Temperature

has risen too, but values vary more year to year



*Local historical data tells us the climate is changing.*

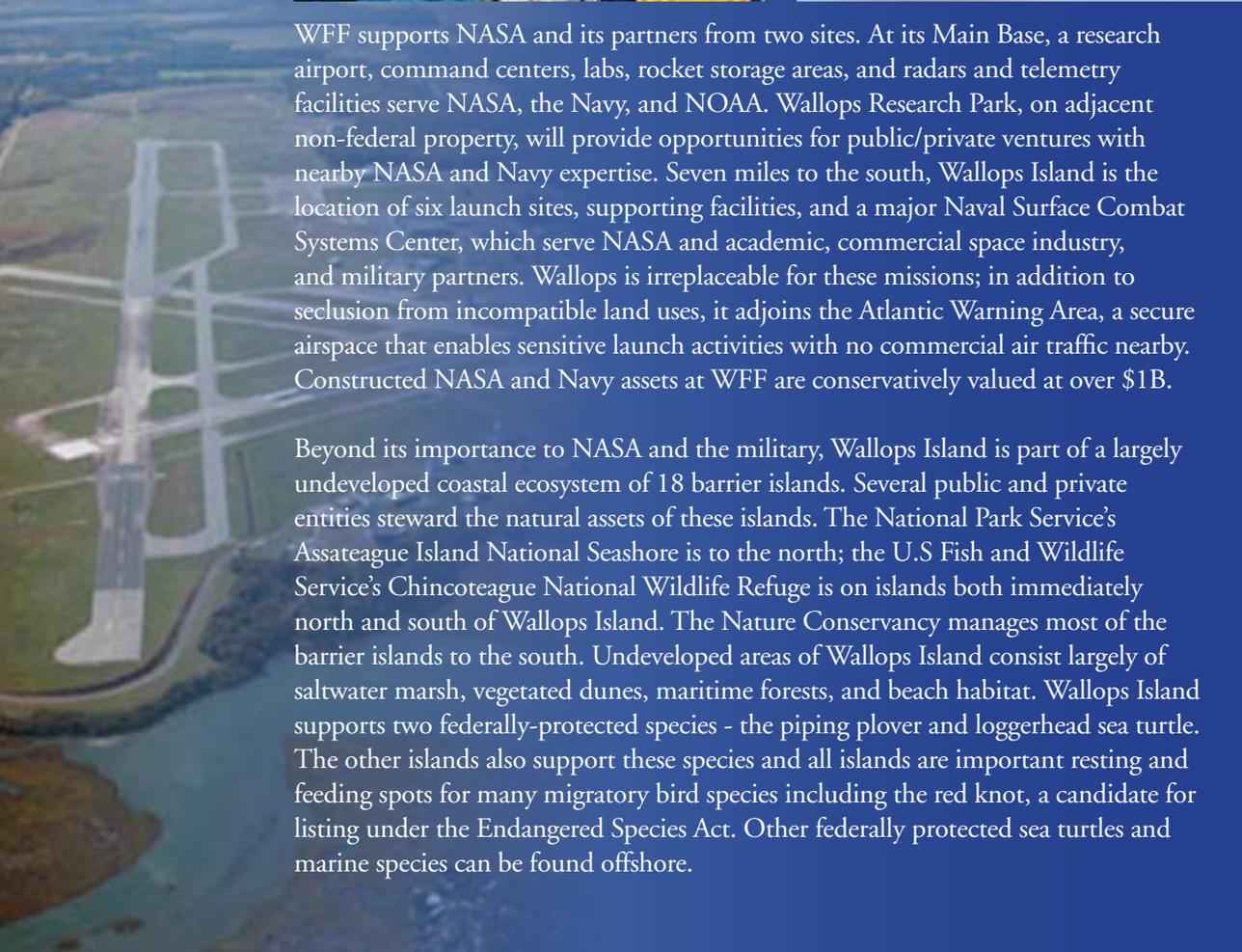
# the setting

NASA Wallops Flight Facility (WFF) occupies nearly 6500 acres on the mainland of the Eastern Shore of Virginia and on Wallops Island, which is part of a long chain of barrier islands along the coastlines of Virginia and Maryland. The Virginia/Maryland border is about 6 miles north of WFF.



# what's at stake?

Wallops Flight Facility (WFF) is NASA's principal facility for suborbital and small orbital research missions. The professionals at Wallops enable relatively low-cost aerospace-based science and technology research critical to the nation. Over 16,000 rockets have launched from WFF since its establishment in 1945. WFF employs about 1,300 NASA civil servants, contractors, and partners, and contributes significantly to the local economy. WFF hosts internship and co-op programs, as well as education programs in local communities and schools.



WFF supports NASA and its partners from two sites. At its Main Base, a research airport, command centers, labs, rocket storage areas, and radars and telemetry facilities serve NASA, the Navy, and NOAA. Wallops Research Park, on adjacent non-federal property, will provide opportunities for public/private ventures with nearby NASA and Navy expertise. Seven miles to the south, Wallops Island is the location of six launch sites, supporting facilities, and a major Naval Surface Combat Systems Center, which serve NASA and academic, commercial space industry, and military partners. Wallops is irreplaceable for these missions; in addition to seclusion from incompatible land uses, it adjoins the Atlantic Warning Area, a secure airspace that enables sensitive launch activities with no commercial air traffic nearby. Constructed NASA and Navy assets at WFF are conservatively valued at over \$1B.

Beyond its importance to NASA and the military, Wallops Island is part of a largely undeveloped coastal ecosystem of 18 barrier islands. Several public and private entities steward the natural assets of these islands. The National Park Service's Assateague Island National Seashore is to the north; the U.S Fish and Wildlife Service's Chincoteague National Wildlife Refuge is on islands both immediately north and south of Wallops Island. The Nature Conservancy manages most of the barrier islands to the south. Undeveloped areas of Wallops Island consist largely of saltwater marsh, vegetated dunes, maritime forests, and beach habitat. Wallops Island supports two federally-protected species - the piping plover and loggerhead sea turtle. The other islands also support these species and all islands are important resting and feeding spots for many migratory bird species including the red knot, a candidate for listing under the Endangered Species Act. Other federally protected sea turtles and marine species can be found offshore.

# projected changes

## The Climate Science Context

Scientists have collected weather and climate data and indicators of longer-term climate patterns (such as ice cores and tree rings) from the entire globe. Based on analyses of these data, plus a growing understanding of physical processes that control climate, scientists have developed sophisticated models that project future climate changes. Many climate models project that climate change will accelerate this century. The US Global Climate Research Program's report summarizes these results at <http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts>. NASA climate scientists are an important part of the international research effort. NASA is a key player in modeling climate variables and collecting both earth-based and space-based data used to develop and validate climate models and identify climate impacts.

## Eastern Shore Area Climate and Weather Today

The climate at WFF and its surrounding region is best described as humid subtropical. Average temperatures in the area range from about 36°F in January to about 76°F in July. Annual precipitation averages 40 inches and is relatively evenly distributed throughout the year. Local climate hazards that impact the center include nor'easters and hurricanes.

## Future Climate Projections

Based on local temperature and sea level records, scientists from NASA's Goddard Institute for Space Studies used local data to refine global climate model outputs, making the projections WFF-specific. This "downscaling" process can provide a more precise projection for a specific location (in this case the WFF area), than modeling for an entire region, such as the East Coast. Using these models,

## Climate Scenarios

The United Nations Intergovernmental Panel on Climate Change (IPCC) developed several greenhouse gas (GHG) emissions scenarios based on differing sets of assumptions about future economic growth, population growth, fossil fuel use, and other factors. The emissions scenarios range from "business-as-usual" (i.e., minimal change in the current emissions trends) to more progressive (i.e., international leaders implement aggressive emissions reductions policies). Each of these scenarios leads to a corresponding GHG concentration, which is then used in climate models to examine how the climate may react to varying levels of GHGs. Climate researchers use many global climate models to assess the potential changes in climate due to increased GHGs. In this case, 3 emissions scenarios were used in 16 different global climate models, to provide a range of possible outcomes and provide a sound basis for policy decisions and adaptation planning.

## Projected Changes in Climate Variables

	2020's	2050's	2080's
 Average Annual Precipitation	0 to +10%	0 to +10%	0 to +15%
 Sea Level (inches)	+2 to +5	+7 to +11	+12 to +21
 Sea Level–Rapid Ice Melt Scenario (inches)	+5 to +9	+19 to +28	+42 to +56
 Average Annual Temperature (F°)	+1.5° to +2.5°	+2.5° to +4.5°	+3.5° to +6.5°

*Average sea levels and temperatures are projected to rise.*

*Temperature and precipitation projections reflect a 30-year average centered on the specified decade; sea levels are averages for the specific decade. Data for 1971-2000 from Wallops Flight Facility provide a baseline for Temperature (56.3°F) and for Annual Precipitation (40.0 inches). Sea level data are for Gloucester Point and Kiptopeke, VA and include the impacts of subsidence in the area. Temperatures are rounded to the nearest half degree, precipitation projections to the nearest 5%, and sea level rise to the nearest inch. Shown are the central range (middle 67% of values) across the GCMs and GHG emissions scenarios. Data are from the NOAA National Climatic Data Center.*

# projected changes

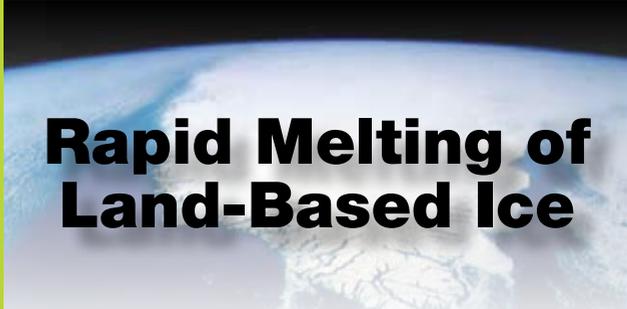
scientists project higher average annual temperatures and rising average sea levels for the Wallops area. While little change is expected in average annual precipitation, storms may be more intense, leading to increased risks of flooding.

## The Case for Adaptation

Because of its location on the Atlantic coast, sea level rise and storm surge may be the biggest threats to WFF. The area has always been subject to hurricanes and nor'easters, and the associated high winds and flooding. The combination of rising sea level and severe storms could produce catastrophic impacts on WFF and the surrounding high profile infrastructure assets, human capital, and natural resources. Projected changes in the frequency of some extreme events like hot and cold days (see tables below) may also lead to large impacts. Most people are more likely to notice the increased frequency of extreme events - more heat waves, more downpours, more flooding - than the gradual rise in average annual temperatures and sea levels. The Facility's future is intricately connected with broader social, economic, and environmental trends expected throughout the region; WFF and its partners in the region will collaborate to develop and implement adaptation strategies for a climate resilient Eastern Shore.

## A Note on Interpreting Climate Projections

Model projections indicate a progressive long-term warming trend for the Wallops area, but they cannot provide an exact temperature for a future date. For example, it cannot be stated that the average temperature at WFF will be 59.3°F in 2043; it is appropriate however to say that between 2040 and 2070, temperatures are projected to increase 2.5 to 4.5 degrees above the average baseline temperature.



## Rapid Melting of Land-Based Ice

Data collected over the past several years reveal that land-based ice, such as that on Greenland and the Western Antarctic Ice Sheet, is melting faster than most Global Climate Models project. Because this could change sea levels substantially, climate scientists developed an alternative projection that incorporates observed and longer-term historical land-based ice melt rates. This rapid ice melt scenario suggests that sea levels could rise three times as fast by the 2080s, resulting in up to 3 additional feet of sea level rise. (see Rapid Ice Melt data in the Climate Variables chart to the left.)

Daily Temperatures	Baseline	2020s	2050s	2080s
Days/year at or above 95°F	2	3 to 5	6 to 11	8 to 21
Days/year at or above 90°F	14	17 to 21	22 to 34	27 to 53
Days/year at or below 40°F	126	106 to 113	94 to 106	82 to 98
Days/year at or below 32°F	73	54 to 61	43 to 54	34 to 48

Baseline is from Wallops Flight Facility

## Extreme Event Changes This Century

Event	Direction of Change	Likelihood
Hot Days	↑	Very Likely
Intense Precipitation	↑	Likely
River Flooding	↑	Likely
Drought	↑	More likely than not
Intense Winds	↑	More likely than not

Based on global climate model simulations, published literature, and expert judgment

### Hot and Cold Day Projections

The number of days per year exceeding 90°F is projected to rise in the coming century, and the number of days with temperatures below 32°F is projected to decrease. More hot days (and fewer cold days) would affect outside work, energy use, agricultural practices, and habitats.

# our responsibility

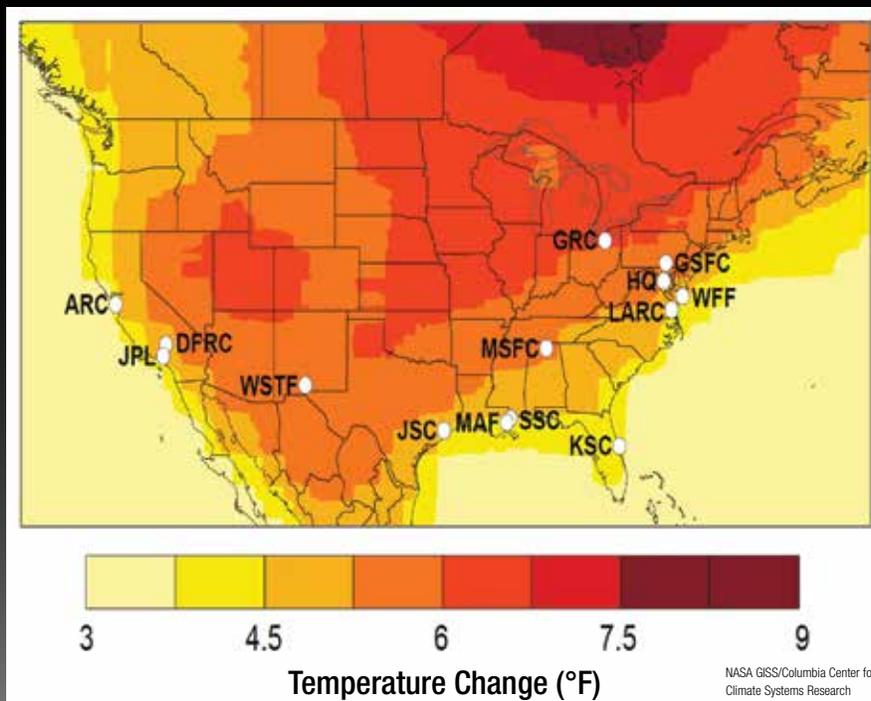
The time to develop and implement adaptation strategies is now. Executive Order 13514 directs federal agencies to assess and manage the effects of climate variables on operations and mission in both the short and long term. A changing climate in the Wallops area will affect facility operations (e.g., water and energy management), natural resources (e.g., new invasive species control), infrastructure that is vital to mission success (e.g., increased cost of protection against flooding), quality of life in the community (e.g., additional heat stress management), and the regions' economy (e.g., increased public expenditures on utilities). By considering these impacts during existing planning and decision-making cycles at Wallops Flight Facility and in collaboration with area partners, impacts to their missions may be abated or reduced. The recent construction of the new beach in front of the launch range, at considerable expense, provides an example of an adaptation measure taken to protect valuable national assets. Adaptation strategies developed for WFF may also prove beneficial to the local community as planners implement short-term tactical changes now, while simultaneously planning for longer-term strategic adaptation measures. Some potential impacts are listed in the chart below.



A new beach built by pumping sand from dredges offshore in 2012 will help protect more than \$1 billion in federal and state government assets located here. The Wallops Island facility is home to NASA, the US Navy Surface Combat Systems Center, and the Mid-Atlantic Regional Spaceport. (upper photo - U.S. Army photo/Patrick Bloodgood)

Climate Trends	Potential Impacts
Rising Sea Level	Exacerbated flooding from storm surges; reduced emergency response capabilities. Increased salinity impacts to drinking water resources and habitats
Increased Coastal Flooding	Impacts to wastewater treatment plants on the coast; damage to infrastructure; changes in shoreline habitats; overloading of stormwater management systems
Overall Increased Temperature	Increased cooling costs in the summer; decreased heating costs in the winter. Changes in plant and animal cycles, including pest and disease vector species
Increased Number of High Temperature Days	Potential for damage to infrastructure materials; potential for limiting work and recreation outdoors; increased health problems related to heat stress
Precipitation Changes	Increased flooding from extreme precipitation events; increased risk of drought as temperatures rise; habitats affected by fluctuating groundwater levels

## Projected Temperature Change (°F), 2080s minus 1980s, A1B Emissions Scenario\*



\*Average projected temperature change across sixteen global climate models for the A1B emissions scenario. The A1B scenario, one of several developed by the IPCC, assumes high CO<sub>2</sub> levels for first the half of the 21st century, followed by a gradual decrease after 2050. Each time period (the 2080s and 1980s) reflects a 30-year average, not a specific point in time. **The precise values shown in the map should not be interpreted as the most likely outcome.** The patterns of future climate change will depend on a range of factors, including the climate system, population, economics, technology, and policy.

### A Note about Downscaling Climate Data Specifically for Individual NASA Centers

The quantitative climate projections in this document are based on global climate model simulations conducted for the IPCC Fourth Assessment Report (2007) from the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project Phase 3 (CMIP3) multi-model dataset. The simulations provide results from sixteen global climate models that were run using three emissions scenarios of future greenhouse gas concentrations. The outputs are statistically downscaled to 1/8 degree resolution (~12 km by 12 km) based on outputs from the bias-corrected (to accurately reflect observed climate data) and spatially-disaggregated climate projections derived from CMIP3 data. Results provide a more refined projection for a smaller geographic area. This information is maintained at: [http://gdo-dcp.ucllnl.org/downscaled\\_cmip3\\_projections](http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections) and described by Maurer, et al. (2007)<sup>1</sup>.

The **rapid ice melt scenario** and qualitative projections reflect a blend of climate model output, historical information, and expert knowledge. For more information about rapid ice melt, see a paper and references at <http://www.nature.com/climate/2010/1004/pdf/climate.2010.29.pdf>.

### Key Uncertainties Associated with Climate Projections

Climate projections and impacts, like other types of research about future conditions, are characterized by uncertainty. Climate projection uncertainties include but are not limited to:

- 1) Levels of future greenhouse gas concentrations and other radiatively important gases and aerosols,
- 2) Sensitivity of the climate system to greenhouse gas concentrations and other radiatively important gases and aerosols,
- 3) Climate variability, and
- 4) Changes in local physical processes (such as afternoon sea breezes) that are not captured by global climate models.

Even though precise quantitative climate projections at the local scale are characterized by uncertainties, the information provided here can guide resource stewards as they seek to identify and manage the risks and opportunities associated with climate variability/climate change and the assets in their care.

<sup>1</sup>Maurer, E.P., L. Brekke, T. Pruitt, and P.B. Duffy (2007), 'Fine-resolution climate projections enhance regional climate change impact studies', *Eos Trans. AGU*, 88(47), 504.

Authorization for NASA's climate risk management efforts, which began in 2005, includes:

- Federal Managers' Financial Integrity Act of 1982, supported by:
  - GAO (1999) Standards of Internal Control in the Federal Government
  - OMB Circular A-123 (2004) Management's Responsibility for Internal Control
- National Security Directive 51 and Homeland Security Presidential Directive 20: National Continuity Policy (9 May 2007) on localized acts of nature
- Presidential Policy Directive 8 – National Preparedness (30 March 2011) for catastrophic natural disasters
- Executive Order 13514 (8 October 2009) Leadership in Environmental, Energy and Economic Performance
- 2010 National Aeronautics and Space Act (51 USC Sec 20101 et seq)
- 2010 National Space Policy of the United States of America

Members of NASA's Climate Adaptation Science Investigator (CASI) Work Group contributed to this document.

